NOTE AS TO THE MEASUREMENT OF THE ACTION OF WATER UPON METALS.

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Reports recording that a water contains so many parts per million of lead, zinc or other metal are common enough, but it is rare to find advance statements of what a water is capable of doing in the way of dissolving metals should opportunity be afforded it of coming in contact with them. In other words, a client who possesses a water supply which is very desirable at its source is seldom informed of the possible damage which may result thereto by reason of its being conveyed through metallic piping.

After the pipes have been laid and the water admitted to them, record is made of the result as to the metallic solvency, but little is found in the nature of a prophecy antedating the outlay of capital; which prophecy had it been uttered in time, might have had material bearing upon the investment. Again, if, as occurs in a few instances, the client be told that the water under examination is capable of acting upon certain metals, he is not given the information in such quantitative form as will enable him to make comparisons between it and other waters with reference to this property.

It is well known that all waters do not equally possess the power to attack metals and it is proper to ask that, granting such power to exist, how far is its exercise objectionable from a sanitary point of view; or, to state it differently, what amount of metallic salts in solution may be allowed with safety?

The interesting case is given of "A water from the tail-race of a gold and silver mill which showed the presence of 350 parts of lead, 51 parts of copper and 1666 parts of arsenic oxide per million of water. This water, which was supposed to have caused the death of a number of cattle, was so highly charged with arsenic that an ordinary drink for man or beast would contain sufficient to kill."[1]

Such a special instance, however, does not come within the limits of the present inquiry.

Let us consider for a moment the question of "plumbism" or lead poisoning, as it is ordinarily presented under the classification of a water-borne disease.

The Massachusetts State Board of Health enumerates the symptoms of lead poisoning as some or all of the following: Anæmia, constipation, indigestion, loss of appetite, thirst, metallic taste, abdominal pain, colic, "drop wrist," blue line at margin of gums, lead in the urine.[2]

Dr. Hunter describing the effects of the epidemic at Pudsey, says: "Anæmia and debility were the most common symptoms. Patients nearly always complained that they felt as if they would sink down from weakness, and that the least exertion would make them sweat freely. The majority had the blue gum-line so characteristic of lead poisoning. Colic was a common symptom. Paralysis was not common, but there were five or six cases of almost general paralysis and in these cases drop-wrist was included. The amount of lead found in the waters producing these effects varied from .01 to 1 grain or more per imperial gallon (.143 to 14.3 per million)."[3]

There is some difference of opinion among the authorities as to the amount of contained lead required to condemn a water, but all are agreed that even small quantities should be narrowly watched. Thus, the Massachusetts reports note that one-half part per million has caused serious injury.[4] Haines holds that .1 grain per U. S. gallon (1.71 per million) should cause a water to be rejected.[5]

Whitelegge believes that "No water should be used for drinking which contains more than one part of lead per million, and any trace, however minute, indicates danger." (Hygiene and Public Health.)

[1] Utah Agr. Expt. Sta. Bull. 81, p. 199.

[2] Report of Mass. State Board of Health, 1898, XXXIII.

[3] Thresh, "Examination of Water," p. 88.

[4] Mass. State Board of Health, 1898, XXXII.

[5] *J. Fk. Inst.*, Nov., 1890.

To quote Dr. Summerville in his recent paper in *Water:* "Lead to the extent of .25 part per million is sufficient to condemn a potable water."

That sundry waters contain enough lead to prevent their acceptance by at least some of the standards above laid down is shown by the fact that a few years ago it was reported that sixty-three (63) cities of Massachusetts possessed public water supplies which contained lead in amounts varying from 85.46 to .023 per million. In four of these cities where lead poisoning was pronounced the average amount of the metal present during ordinary daytime use was one part or over per million. Occasional instances of "plumbism" were noticed in other towns and doubtless mild or unrecognized cases occurred elsewhere.[1]

In the 31st annual report of the London local Government Board (1901 and 1902 Supplement on Lead Poisoning and Water Supply, Vol. 2, page 426), peaty moorland waters are shown to be especially plumbo-solvent, to a degree chiefly governed by the amount of acidity present, and experiments show that such acidity is due, at least in part, to acid-forming bacteria residing in the peat.

For instance, the influence of acidity is shown by the action of the following moorland waters from Lancashire and Yorkshire:[2]

Acidity of water in terms of c.c. of N/10 Na_2Co_3 required to neutralize 100 c.c. of the water.	Milligrams of Pb. in 100 c.c. of the water after filtering through lead shot.
0.2	.28
.3	.25
.4	.4
.5	.66
.6	.92
.8	1.5
.9	2.4
1.1	3.2
2.2	8.6

The London report already quoted is so firm in its belief that the cause of plumbo-solvency has been located that it ventures to rate moorland waters as "safe" if they are neutral to lacmoid and as "dangerous" if they react acid with that indicator. Attention

[1] Mass. State Board of Health, 1898, p. 543.

[2] Thresh, "Examination of Water," p. 186.

is also called therein to the fact that moorland streams are highest in acidity during wet weather because of drainage from peaty surface sources and less so during periods of no rain on account of their supply at such seasons coming from the flow of springs.

In this connection it may be noted that H. W. Clark observed that carbonic acid in a soft water was the main factor that caused lead to be taken into solution by the waters of Massachusetts.[1]

It is by no means new to distinguish between the "solution" of lead and that "erosion" of the metal which some waters exercise whereby insoluble lead salts are formed with appreciable increase in the turbidity of the water.

Such classification of the action upon lead has been developed by the report of the London Local Government Board with great care.

For our purposes it will suffice to note that "erosion" does not occur in the absence of oxygen, and we are also to remember that from the sanitarian's point of view "erosion" may be fully as objectionable as "solution" if no opportunity for clarification be furnished. In fact, the former may readily be the greater evil of the two, because of its involving the possibility of the ingestion of large quantities of lead salts held in suspension.

Piping water in tubes of galvanized iron is very common, and as zinc is often more easily attacked than lead it is pertinent to ask if it be equally dangerous. So far as our present experience can guide us towards a correct solution of this question, the reply must be a negative one and the following opinions are presented in support of such contention:

In the journal of the German Society of Gas and Water Engineers for 1887 H. Bante collected statistics to show "that the use of galvanized pipes should be in no way detrimental to health."

Similar views are entertained by V. Ehmann, director of the water supply of Wurtemberg.[2]

According to Thresh[3] "There is no doubt that waters containing traces of zinc are used continuously for long periods without

[1] *Engineering News,* Dec. 1, 1904.

[2] *J. Fk. Inst.,* Nov., 1890.

[3] Examination of Waters and Water Supplies, p. 85.

causing any obvious ill effects. The water supply to a small hospital with which I was connected for some years always contained a trace of zinc, probably never more than half a grain of the carbonate per imperial gallon (7.1 parts per million), but I never observed any indications of its being deleterious, although such effects were looked for."

In the Massachusetts Board of Health report for 1900, page 495, the following table is given showing amounts of zinc in sundry public supplies, the metal having been dissolved from pipes of galvanized iron or brass during ordinary use. The results are averages and are in part per million.

West Berlin	18.46
Milbury	3.08
Newton	1.25
Marblehead	0.85
Grafton	0.73
Wellesley	0.68
Fairhaven	0.52
Lowell	0.33
Webster	0.28
Sheffield	8.65
Palmer	2.90
Beverly	2.71
Fall River	0.07

The first of the above, West Berlin, drew its water through four thousand feet of galvanized iron pipes. The quantity of metal dissolved therefrom was certainly large but appears to have produced no evil results. "As far as is known the amount of zinc present in these waters as used is not sufficient to have any effect upon the health of the consumers of the water."

"The Board has investigated the question of the presence of zinc in drinking water supplies where galvanized iron pipes are used and, except in case of the use of some ground waters, containing very large amounts of free carbonic acid, which dissolves zinc and many other metals very freely, the amount of zinc found in ordinary water supplies, where galvanized pipes are used, is not sufficient, in the opinion of the Board to give anxiety."[1]

[1] Massachusetts Board of Health, 1902, XLIII.

In a private letter of more recent date the president of the above mentioned board says: "If there had been any harmful effects of the presence of zinc in the public drinking waters of the state that fact would have undoubtedly been brought to our attention. No statement to this effect has been made, nor has there seemed to this board reason suspecting serious danger from this source."

As an instance of long continued use of a water containing much zinc, the case of Brisbane, Queensland, should be quoted. In that city rainwater tanks built of galvanized iron are found in all the houses. The water, which is in common use, contains about 17.1 parts per million of zinc, yet no harmful effects have been observed.[1]

In his experience the writer has been unable to trace any evil effect due to the presence of zinc in drinking water, even when the quantity rose as high as 23 parts per million in a water which is in constant use. It might be well to add, that in the particular case just cited the zinc was derived from a long stretch of galvanized iron pipes and the amount of the metal present was subject to great and frequent fluctuations for reasons that were not apparent.

It must be admitted however, that, even on the assumption that the presence of zinc in a water is of no sanitary significance, its being there is nevertheless not desirable, and the probability of a supply being able to dissolve it should be determined and reported.

What can now be said with reference to some convenient and standard method of reporting the possible action of water upon any of the common metals?

The suggestion offered is this:—Let the action, whether solution or erosion, be stated in parts per million, and let it be that of one litre of water acting upon one square decimeter of bright metal for one hour at 15° Centigrade.

The mode of procedure followed by the writer is to submerge a piece of bright sheet metal, one decimeter square in two liters of water contained in a wide-mouthed bottle. The water is oc-

[1] Hazen, *Eng. News,* April 4, 1907.

casionally given a gentle motion and is kept at 15 degrees for one hour, after which time the metal in solution or suspension is determined. One hour is sufficient time to allow of the watching of metallic solvency, and let it be added, the limiting of the time of action to the standard period is important, for the rate of action of the same water is not only variable but the ratio of the total action during different lengths of time is not a simple one. Thus, the quantity of metal attacked in ten hours is by no means ten times that acted upon during one hour.

In conclusion, let it be said that although we know in a general way that softness, acidity, dissolved gases and the presence of much chloride or nitrate will tend towards metallic action, while alkalinity and hardness are rated as protective agents, yet it is far better to actually test a water with reference to its behavior towards metals than to attempt any prophecy of its action based upon analytical knowledge of what the water may contain.

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